CHAPTER 29

Palpation and Percussion of the Chest

KEY TEACHING POINTS

- Asymmetric chest expansion greatly increases the probability of disease in the side that moves less (e.g., ipsilateral pneumonia, pleural effusion). The sensitivity of the sign, however, is low.
- In patients with respiratory complaints, diminished tactile fremitus and dullness to percussion significantly increase the probability of underlying pleural effusion, whereas symmetric tactile fremitus and symmetric resonance decrease probability of pleural effusion.
- Of the three original techniques for percussion (comparative, topographic, and auscultatory percussion), only comparative percussion is widely used today. Abnormal dullness using comparative percussion accurately indicates underlying disease, although a chest x-ray will be necessary to define this disease.

PALPATION

I. INTRODUCTION

Palpation of the chest is limited because the bony rib cage conceals many abnormalities of the underlying lungs. The traditional reasons to palpate the chest are to detect the following signs: (1) chest wall tenderness or masses, (2) pleural friction rubs, (3) bronchial fremitus, (4) abnormal respiratory excursion, and (5) asymmetrical tactile fremitus. Bronchial fremitus is an inspiratory vibratory sensation felt in some patients with airway secretions. Respiratory excursion is assessed while the patient breathes in and out, by either simultaneously palpating symmetric areas of the chest or measuring the changing circumference with a tape measure. According to traditional teachings, chest excursion is reduced bilaterally in chronic airflow obstruction and neuromuscular disease (see Chapter 33) and unilaterally in pleural effusion or consolidation.

II. TACTILE FREMITUS

A. THE FINDING

Tactile fremitus (vocal fremitus) is the vibration felt by the clinician's hand resting on the chest wall of a patient who is speaking or singing.

B. TECHNIQUE

To elicit the sign, the patient usually says "one, two, three," or "ninety-nine" repeatedly and evenly while the clinician compares symmetric areas of the chest. Some early German physical diagnosticians used the word *neun-und-neuzig* (German for "ninety-nine") to elicit vocal fremitus, prompting modern English-speaking authors to suggest that the "oy" sound is necessary to elicit the finding (e.g., "toy boat" or "Toyota," to mimic the vowel sound in the German word *neun-und-neunzig*). However, this is incorrect, and the early German diagnosticians just as often used other words, such as "one, one, one" (*eins, eins, eins*) and "one, two, three" (*eins, zwei, drei*),[1-3] or had their patients sing or scream to elicit the finding.[3]

C. FINDING

Vocal fremitus is more prominent in men than women because men have lower-pitched voices, which conduct more easily though lung tissue than do higher-pitched voices (see the section on Pathogenesis of Vocal Resonance in Chapter 30). Therefore tactile fremitus may be absent in some healthy persons, especially those with high-pitched or soft voices or those with thick chest walls (which insulate the hand from the vibrating lung). Consequently, only *asymmetric* tactile fremitus is an abnormal finding; according to traditional teachings, fremitus is asymmetrically diminished whenever air, fluid, or tumor pushes the lung away from the chest wall (*unilateral* pneumothorax, pleural effusion, neoplasm) and is asymmetrically increased when there is consolidation of the underlying lung (i.e., *unilateral* pneumonia).

The pathogenesis of tactile fremitus is discussed in Chapter 30 (section on Vocal Resonance).

III. CLINICAL SIGNIFICANCE

A. CHEST EXPANSION

Just as is traditionally taught, the finding of asymmetric chest wall expansion increases the probability of unilateral pneumonia in patients with cough and fever (the side with pneumonia moves less, likelihood ratio [LR] = 44.1; EBM Box 29.1), and it increases the probability of underlying pleural effusion in hospitalized patients with respiratory complaints (LR = 8.1). After intubation of a patient, asymmetric chest wall expansion increases the probability of right mainstem bronchus intubation (LR = 15.8).

Nonetheless, the opposite finding—*symmetric* chest expansion—does *not* change the probability of either pneumonia or endobronchial intubation, although it does decrease the probability of underlying pleural effusion (LR = 0.3). The physical examination should never be used as the sole tool confirming placement of an endotracheal tube after intubation.

B. TACTILE FREMITUS

In a study of 278 patients hospitalized with respiratory complaints, the finding of asymmetric diminished tactile fremitus significantly increased the probability of an underlying pleural effusion (LR = 5.7; see EBM Box 29.1); symmetric fremitus decreased the probability of effusion (LR = 0.2).

C. CHEST WALL TENDERNESS

According to traditional teachings the finding of chest wall tenderness in a patient with chest complaints suggests benign disease, commonly referred to as

costochondritis. Even so, this conclusion is accurate only in patients with acute atraumatic chest pain, in whom chest wall tenderness decreases the probability of myocardial infarction (LR = 0.3; see EBM Box 29.1). In contrast, in studies of pneumonia, chronic coronary artery disease, and pulmonary embolism, the finding has little diagnostic value, occurring just as often in serious disease as in benign disorders (LRs not significant; see EBM Box 29.1).

EBM BOX 29.1

*Diagnostic Accuracy of Palpation of the Chest**

Finding (Reference)	*Sensitivity (%)*	*Specificity (%)*	**Likelihood Ratio† if Finding Is**	
			Present	*Absent*
Asymmetric Chest Expansion				
Detecting pneumonia in patients with acute cough[4]	5	100	**44.1**	NS
Detecting pleural effusion in hospitalized patients with respiratory complaints[5]	74	91	**8.1**	**0.3**
Asymmetric chest wall movements after intubation, detecting right mainstem bronchus intubation[6,7]	32-50	98	**15.8**	0.6
Diminished Tactile Fremitus				
Detecting pleural effusion[5]	82	86	**5.7**	**0.2**
Chest Wall Tenderness				
Detecting pneumonia in patients with acute cough[8]	5	96	NS	NS
Detecting pulmonary embolism in patients with pleuritic chest pain[9,10]	11-17	79-80	NS	NS
Detecting coronary artery disease in outpatients with chronic chest pain[11-14]	1-69	16-97	0.8	NS
Detecting myocardial infarction in patients with acute nontraumatic chest pain[15-17]	3-15	64-83	**0.3**	1.3

*Diagnostic standard: For *pleural effusion*, chest radiograph, for *pulmonary embolism*, *coronary artery disease*, and *myocardial infarction*, see Chapters 34 and 49.
†Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.
NS, Not significant.

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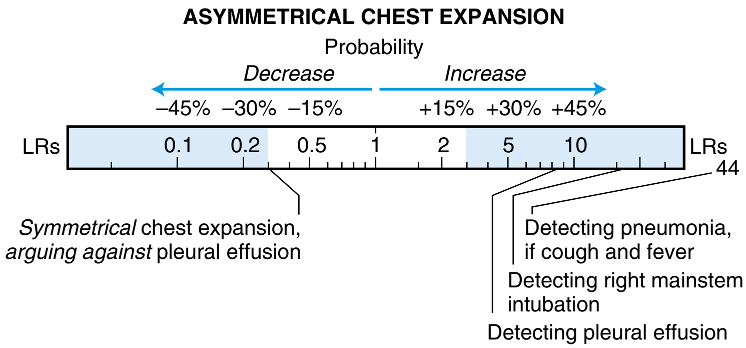

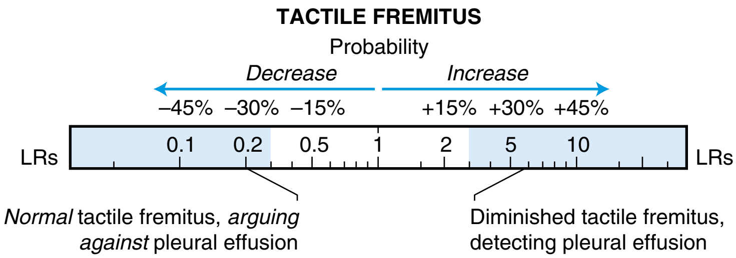

PERCUSSION

I. INTRODUCTION

In 1761, after studying patients and cadavers at the Spanish Hospital in Vienna for 7 years, Leopold Auenbrugger published a 95-page booklet containing the first detailed description of chest percussion.[18] His work was largely ignored for half a century, until Corvisart (physician to Napoleon) translated it into French and taught the technique to his students, including Laennec, the subsequent inventor of the stethoscope.[19] The discovery of percussion was a major diagnostic advance because, for the first time, clinicians could reliably distinguish empyema from tuberculosis and other pneumonias.[19] Until the discovery of roentgen rays in 1895, percussion and auscultation were the only methods to investigate and define diseases of the lungs during the patient's life.

II. TECHNIQUE

A. DIRECT VERSUS INDIRECT METHOD

In the direct method the percussion blow lands directly on the body wall (the method of Auenbrugger and Laennec). In the indirect method the blow falls instead on an intervening substance, called a pleximeter, placed against the

body wall. Historically, pleximeters were made of ivory or wood, or a coin was used, although today most clinicians use the middle finger of their left hand.

B. TYPES OF PERCUSSION

There are three ways to percuss the patient: (1) comparative percussion (the original method of Auenbrugger and Laennec), (2) topographic percussion (invented by Piorry of France in 1828),[20,21] and (3) auscultatory percussion (introduced by the Americans Camman and Clark in 1840).[19,22] Nowadays most clinicians use the indirect method with comparative and topographic percussion and the direct method with auscultatory percussion.

1. COMPARATIVE PERCUSSION

Comparative percussion identifies disease by comparing the right and left sides of the chest. Prominent dullness or unusual hyperresonance over one side indicates disease in that part. By definition, bilateral disease is more difficult to identify using comparative percussion.

2. TOPOGRAPHIC PERCUSSION

Topographic percussion attributes any dullness in the chest or abdomen to airless intrathoracic tissue lying directly beneath the percussion blow. Topographic percussion differs from comparative percussion in implying the clinician can precisely outline the borders of underlying organs and then measure their span. The technique is still used today to measure excursion of the diaphragm (and to identify an enlarged heart or liver; see Chapters 37 and 51).

When using topographic percussion to determine diaphragm excursion, the clinician locates the point of transition between dullness and resonance on the lower posterior chest, first during full inspiration and then during full expiration. The diaphragm excursion is the vertical distance between these two points. The reported normal excursion of healthy persons ranges from 3 to 6 cm (for comparison, the corresponding excursion on the chest radiograph is approximately 5 to 7 cm in normal persons and 2 to 3 cm in patients with lung disease).[19,23,24]

3. AUSCULTATORY PERCUSSION

Auscultatory percussion was introduced to further refine the goals of topographic percussion.[22] Instead of listening to sounds as they resonate off the chest into the surrounding room, the clinician using auscultatory percussion places the stethoscope on the body wall and listens through it to the sounds transmitted by nearby percussive blows.

Since the mid-1800s, auscultatory percussion of the chest has repeatedly fallen out of favor and then resurfaced as a "new sign."[19] In the most recent version of auscultatory percussion of the chest, introduced in 1974, the clinician taps lightly over the manubrium and listens over the posterior part of the chest with the stethoscope.[25,26] Using this technique, the clinician should find identical sounds at corresponding locations of the two sides of the chest; a note of decreased intensity on one side supposedly indicates ipsilateral disease between the tapping finger and stethoscope.

The technique of using auscultatory percussion to detect pleural fluid, first developed in 1927,[27] is slightly different. The clinician places his stethoscope on the posterior chest of the seated patient, 3 cm below the twelfth rib, and percusses the posterior chest from apex to base. At some point the normal dull note changes to an unusually loud note: if this occurs with strokes above the twelfth rib, the test is abnormal, indicating pleural fluid.[28]

C. PERCUSSION BLOW

1. FORCE

Each percussion blow should strike the same part of the pleximeter with identical force, and the pleximeter finger should be applied with the same force and orientation when comparing right and left sides. Consistent technique is important because both the percussion force and the pleximeter govern the percussion sound produced. Lighter strokes produce sounds that are duller than those produced by stronger strokes. Lifting the pleximeter finger, even slightly, can transform a resonant note into a dull one.

Even though a consistent technique is important, the force and speed of percussion blows vary threefold among different clinicians,[29] which probably explains why interobserver agreement for topographic percussion is poor compared with that for other physical findings (see Chapter 5).

2. RAPID WITHDRAWAL OF PLEXOR

The traditional teaching is that the plexor finger should be promptly withdrawn after a blow, mimicking the action of a piano key striking a string. The only study of this found that clinicians could not distinguish the note created by a rapid withdrawal from one in which the plexor finger lightly rested on the pleximeter after the blow.[30]

III. THE FINDING

A. PERCUSSION SOUNDS

There are three percussion sounds—**tympany** (normally heard over the abdomen), **resonance** (heard over normal lung), and **dullness** (heard over the liver or thigh) (Fig. 29.1). Tympany differs from resonance and dullness because it contains vibrations of a dominant frequency, which allows the clinician to actually identify its musical pitch. In contrast, resonance and dullness are "noise" in an acoustical sense, consisting of a jumble of frequencies that prevent identification

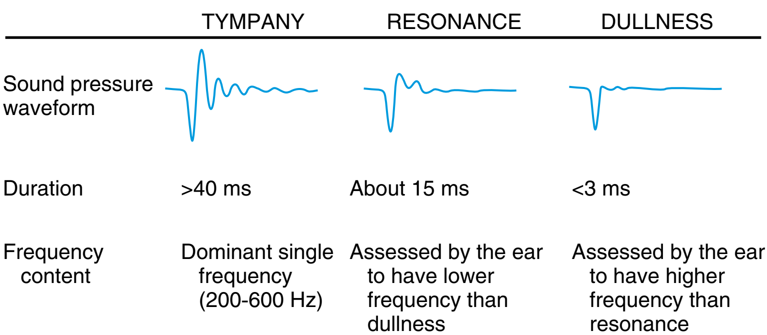

FIG. 29.1 THE PERCUSSION SOUNDS. In the older literature, synonyms for resonance were "full," "clear," "distinct"; synonyms for dullness were "empty," "not distinct," and "thigh" sound. Based upon references 19 and 31.

of a specific musical pitch. The three sound characteristics distinguishing resonance and dullness are intensity, duration, and frequency content; resonance is louder and longer and contains more low-frequency energy.[19,31] Of these three sound characteristics, clinicians appreciate most easily that resonance is louder than dullness.

Some clinicians take advantage of resonance being louder than dullness and apply a technique called threshold percussion, in which percussion blows are so light that dull areas produce no sound. As the blows move along the body wall with precisely the same amount of force, a note abruptly appears the moment the blow encounters a resonant area. An old adage in percussion, attributed to Weil, is that it is much easier to distinguish "something from nothing" than to distinguish "more from less."[19]

B. SENSE OF RESISTANCE

All great teachers of percussion have emphasized that the tactile sense in the pleximeter finger provides as much information as the audible notes. Dull areas, according to these teachers, move less or offer more resistance than resonant areas (thus earning pleural effusion the descriptor "stony dullness"). Experiments using lightweight accelerometers taped to the pleximeter finger confirm that dull areas do move less than resonant areas.[32]

C. GLOSSARY OF ADDITIONAL PERCUSSION TERMS

Historically, the vocabulary of clinical percussion was diverse. Some of the more commonly used terms appear below.

1. SKODAIC RESONANCE

Skodaic resonance is a hyperresonant note produced by percussion of the chest above a pleural effusion. The cause of this finding is unknown. Skodaic resonance was originally described by Josef Skoda,[33] a champion of topographic percussion and the first to apply the principles of physics to percussion.

2. GROCCO TRIANGLE

The **Grocco triangle** is a right-angled triangle of dullness found over the posterior region of the chest *opposite* a large pleural effusion. The horizontal side of the triangle follows the diaphragm for several centimeters; the vertical side lies over the spinous processes but usually ends below the top level of the effusion.[19] This finding was originally described by Koranyi (Hungary, 1897) and later by Grocco (Italy, 1902) and Rauchfuss (Germany, 1903).

3. METALLIC RESONANCE (AMPHORIC RESONANCE; COIN TEST)

Metallic resonance is a pure tympanitic sound containing very high frequencies, found over large superficial pulmonary cavities or pneumothoraces.[33,34] Flicking the tense cheek while holding the mouth open mimics the sound. The sound was best elicited with a hard plexor and pleximeter (e.g., two coins) and is best perceived through the stethoscope or with the examiner's ear near the patient's chest.[19]

4. KRÖNIG ISTHMUS

Krönig isthmus is a narrow band of resonance over each lung apex that lies between the dullness from the neck and the dullness from the shoulder muscles. Diseases of the lung apex, such as tuberculosis, supposedly reduced the width of the band.[19] Georg Krönig (Germany) described the finding in 1889.[35]

5. CRACKED-POT RESONANCE

Cracked-pot resonance is a percussion sound over superficial tubercular cavities, mimicked by pressing the palms together and hitting the back of one hand against the knee.[33,36] To detect the sound in patients, the clinician delivers a strong percussion blow and listens near the patient's open mouth.[2,37] Although the sound was traditionally attributed to the sudden efflux of air through bronchi communicating with a tubercular cavity, the only published pathologic study found no bronchial communication in 11 patients with this sound.[38]

IV. PATHOGENESIS

A. TOPOGRAPHIC PERCUSSION VERSUS CAGE RESONANCE THEORY

From the earliest days of percussion, two opposing theories have explained the genesis of percussion sounds: the **topographic percussion theory** and **cage resonance theory**. The topographic percussion theory argued that only the physical characteristics of the soft tissues directly beneath the percussion blow controlled whether resonance or dullness was produced. This theory emphasized that the body wall itself contributed little to the resulting sound but acted merely to convey the vibrations from the underlying tissues (much like a diaphragm in a microphone transmits the sound vibrations imparted to it). A fundamental tenet of the topographic percussion theory was the **several centimeter rule**, advanced by Weil in 1880,[39] which stated that the percussion stroke penetrated only the most superficial 4 to 6 cm of tissue, and only anatomic abnormalities in this layer influenced the sound produced.

In contrast, the cage resonance theory argued that the percussion sound reflected the ease with which the body wall vibrates, which in turn was influenced by many variables, including the strength of the stroke, the condition and state of the body wall, and the underlying organs. Advocates of the cage resonance theory argued that precise topographical percussion was impossible because underlying organs or disease could cause dullness to occur at distant sites.

The topographic percussion theory became very popular—largely through the persuasive efforts of renowned clinical teachers, including Piorry, Skoda, Mueller, and Mueller's pupil, Ralph Major, who wrote one of the most popular American physical diagnosis textbooks.[1] Nonetheless, the evidence cited to support this theory and the several centimeter rule was meager and of uncertain relevance:[19] it included only a few experiments with cadavers[39] and some sound recordings of exenterated lung slices as they were being percussed.[40]

In contrast, considerable evidence supports the cage resonance theory.

1. ANALYSIS OF SOUND RECORDINGS

The percussion sound contains more frequencies than can be explained by vibrations of just the area of the body wall percussed.[32,41-43] Areas of the body wall distant to the blow must also vibrate and contribute to the sound.

2. CONDITION AND STATE OF THE BODY WALL

External pressure on the chest—from a pillow, a stretcher, or an extra hand placed near the point of percussion—impedes chest wall motion and dampens the percussion note.[34,44]

Pressure against the inner wall of the chest of cadavers also causes dullness, even in areas of the body wall distant from where the pressure is applied.[34] The best clinical

example of the distant effects of internal pressure is the Grocco triangle, a right-angled triangle of dullness found over the posterior region of the chest *opposite* a large pleural effusion (see earlier discussion). The Grocco triangle demonstrates that pressure on the chest wall at one point (e.g., from pleural fluid) may cause dullness at sites distant to that pressure (i.e., over the opposite chest). Even in patients without pleural fluid, external pressure on one side of the posterior chest from a hand or water bottle will produce the Grocco triangle on the opposite chest.[45,46]

Heavier patients have larger liver spans than patients who weigh less,[47] not because the livers of heavier patients are larger, but instead because the excess subcutaneous fat influences the cage resonance and dampens the vibrations, resulting in more dullness and larger spans.

3. STRENGTH OF THE PERCUSSION BLOW

The strength of the blow influences whether resonance or dullness is produced, especially near areas of the body wall marking the transition between resonance and dullness. For example, in percussion of the liver, the span of the liver is approximately 3 cm smaller when using strong strokes than it is when using light strokes (see Chapter 51).[47-49] This occurs because the heavy stroke, when located near where the liver touches the body wall, more easily generates the vibrations necessary for the resonant note, whereas the light stroke is insufficient until further removed. These findings contradict the assertion of topographic percussionists, who taught that stronger blows penetrated tissues more deeply than softer ones; if this were true, percussion of the liver with heavy strokes should produce a larger span than with light strokes (because heavier strokes would detect the dome of the liver, which is removed from the body wall).

B. AUSCULTATORY PERCUSSION

The advocates of auscultatory percussion believe that sound waves travel directly from the tapping finger through the lung to the stethoscope and are altered along the way by diseased tissue. However, it is much more likely that these sounds are conducted circumferentially in the chest wall, for several reasons: (1) The technique fails to detect the heart, which should render some notes of the left chest more dull if sound waves traveled directly to the stethoscope. (2) Sound recordings during auscultatory percussion are the same whether the patient breathes room air or a mixture of helium and oxygen.[50] Because sound characteristics depend on the gas density of the conducting medium, which is different for the two gas mixtures, it is unlikely sound travels through the lung. (3) The characteristics of the sound change during the Valsalva and Mueller maneuvers, which increase tension in the chest wall but do not alter the underlying lung.[50] (4) Contour maps reveal that the loudest sounds during auscultatory percussion appear over bony prominences, such as the scapula, indicating that the sound produced depends on the contour of the chest wall. The intervening lung contributes less to the sound heard because these sound maps do not change even when there is a large underlying tumor.[51]

V. CLINICAL SIGNIFICANCE

A. COMPARATIVE PERCUSSION

EBM Box 29.2 shows that asymmetric dullness is a helpful though infrequent finding that increases the probability of pneumonia in patients with fever and cough (LR = 3), for underlying abnormalities on the chest radiograph of unselected

EBM BOX 29.2
*Diagnostic Accuracy of Percussion of the Chest**

Finding (Reference)†	Sensitivity (%)	Specificity (%)	Likelihood Ratio‡ if Finding Is	
			Present	Absent
Comparative Percussion				
Percussion Dullness				
Detecting pneumonia in patients with fever and cough[4,52-55]	4-26	82-99	**3.0**	NS
Detecting any abnormality on chest radiograph[56-58]	8-15	94-98	**3.0**	NS
Detecting pleural effusion in patients with respiratory complaints[5]	89	81	**4.8**	**0.1**
Hyperresonance				
Detecting chronic airflow obstruction[59,60]	21-33	94-98	**7.3**	0.8
Topographic Percussion				
Diaphragm Excursion <2 cm				
Detecting chronic airflow obstruction[59]	13	98	NS	NS
Auscultatory Percussion				
Abnormal Dullness				
Detecting any abnormality on chest radiograph[56-58]	16-69	74-88	NS	NS
Detecting pleural fluid[5,28]	58-96	85-95	**8.3**	NS

*Diagnostic standard: For *pneumonia* or *pleural effusion,* infiltrate or effusion on chest radiograph; for *chronic airflow obstruction,* FEV1 <60% predicted or the FEV1:FVC ratio <0.6-0.7.

†Definition of findings: For *abnormal dullness during auscultatory percussion for chest radiograph abnormalities*, asymmetric dullness, with stethoscope on posterior chest and while directly percussing sternum anteriorly; for *abnormal dullness during auscultatory percussion for pleural fluid*, transition to unusually loud note above 12th rib posteriorly in midclavicular line, with stethoscope 3 cm below 12th rib and while directly percussing posterior chest from apex to base.[28]

‡Likelihood ratio (LR) if finding present = positive LR; LR if finding absent = negative LR.

FEV1, Forced expiratory volume in 1 s; *FVC,* forced vital capacity; *NS,* not significant.

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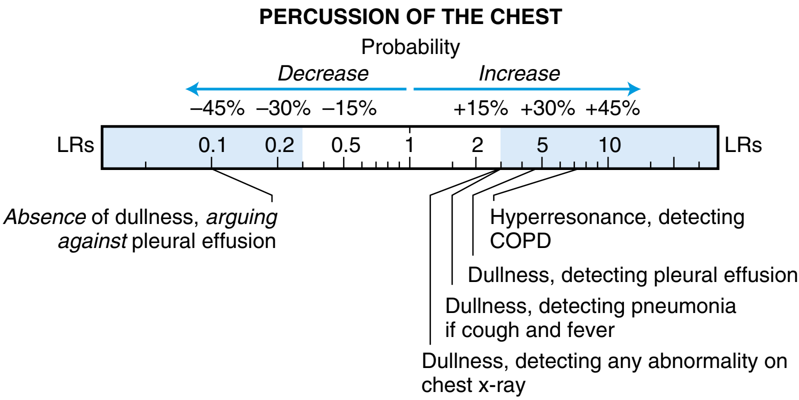

patients (LR = 3), and for pleural effusion in hospitalized patients with respiratory complaints (LR = 4.8). In these studies, percussion detected all large pleural effusions (sensitivity 100%), but very few consolidations (sensitivity 0% to 15%) and no intraparenchymal nodules or granulomas. The presence of normal resonance decreases significantly the probability of underlying pleural effusion (LR = 0.1) but does not change the probability of other significant lung pathology.

In chronic smokers, hyperresonance of the chest is a valuable finding increasing the probability of chronic airflow obstruction (LR = 7.3; see EBM Box 29.2).[59]

B. TOPOGRAPHIC PERCUSSION OF THE DIAPHRAGM

In patients with lung disease, clinicians usually overestimate the actual movements of the diaphragm and differ from the chest film by 1 to 3 cm.[23,61] The correlation between actual and percussed movements is poor in the only study of this finding (r = 0.14 to 0.42, not significant half the time).[23] Another study showed that a percussed diaphragm excursion of less than 2 cm is an infrequent and unreliable diagnostic sign of chronic obstructive lung disease (LRs not significant; see EBM Box 29.2).[59]

C. AUSCULTATORY PERCUSSION

Studies of auscultatory percussion have widely varying results, usually showing the technique has greater sensitivity than comparative percussion but also lower specificity. Overall, the pooled results show that this technique is an unreliable diagnostic sign (both positive and negative LRs not significant; see EBM Box 29.2).

Like conventional percussion, auscultatory percussion identifies most pleural effusions (sensitivity 58% to 96%; see EBM Box 29.2). A positive result (see the section on Auscultatory Percussion for definition of technique) significantly increases the probability of pleural effusion (LR = 8.3).

The references for this chapter can be found on www.expertconsult.com.

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